

CLAIMS

1. A ranging apparatus comprising an illumination means for illuminating a scene with a projected two dimensional array of light spots, a detector for detecting the location of spots in the scene and a processor adapted to determine, from the detected location of a spot in the scene, the range to that spot.
2. A ranging apparatus as claimed in claim 1 wherein the illumination means and detector are arranged such that each spot in the projected array appears to move in the detected scene, from one range to another, along an axis and the axis of apparent motion of each adjacent spot in the projected array is different.
3. A ranging apparatus as claimed in claim 1 or claim 2 wherein the illumination means is adapted to project an array of spots which is focussed at a first distance and unfocussed at a second distance, the first and second distances being within the operating range of the apparatus.
4. A ranging apparatus as claimed in claim 3 wherein the illumination means is adapted to project an array of spots which are non-circular in shape when focussed.
5. A ranging apparatus as claimed in any preceding claim wherein the processor is adapted to resolve any possible ambiguity in range to each spot.
6. A ranging apparatus as claimed in any preceding claims wherein the illumination means has a large depth of field.
7. A ranging apparatus as claimed in any preceding claim wherein the illumination means is adapted to periodically alter the two dimensional array of projected spots.

8. A ranging apparatus as claimed in claim 7 wherein the illumination means is adapted to illuminate the scene cyclically with different arrays of spots.
9. A ranging apparatus as claimed in claim 7 wherein the processor is adapted to determine any areas of ambiguity in the detected array and deactivate one or more of the projected spots so as to resolve the ambiguity.
10. A ranging apparatus as claimed in any preceding claim wherein the illumination means is adapted to so as to produce an array of spots wherein at least some projected spots have a different characteristic to adjacent spots.
11. A ranging apparatus as claimed in claim 10 wherein the characteristic is colour.
12. A ranging apparatus as claimed in claim 10 or claim 11 wherein the characteristic is shape.
13. A ranging apparatus as claimed in any of claims 1 to 9 wherein the spots comprise intersections between continuous lines.
14. A ranging apparatus as claimed in claim 13 wherein the illumination means projects two sets of regularly spaced lines, the two sets of lines being substantially orthogonal.
15. A ranging apparatus as claimed in claim 14 wherein the processor is adapted to determine the range to the intersections between the continuous lines and then, using the determined range information determine the range to other points on the continuous lines.
16. A ranging apparatus as claimed in any preceding claim wherein the detector comprises a two dimensional CCD or CMOS array.

17. A ranging apparatus as claimed in any preceding claim wherein the illumination means is adapted such that the two dimensional array of spots are infrared spots.
18. A ranging apparatus as claimed in claim 17 wherein the detector is adapted to capture a visible image of the scene as well as the location of the infrared spots in the scene.
19. A ranging apparatus as claimed in any preceding claim wherein the baseline between the illumination means and the detector is between 50 and 100mm.
20. A ranging apparatus as claimed in any preceding claim wherein the detection system is adapted to image the scene from more than one direction.
21. A ranging apparatus as claimed in claim 18 wherein the apparatus includes scanning optics in the optical path to the detector adapted to periodically redirect the viewing direction of the detector.
22. A ranging apparatus as claimed in claim 20 wherein the detector comprises two detector arrays each detector array arranged so as to image the scene from a different direction.
23. A ranging apparatus as claimed in any of claims 1 to 19 wherein the apparatus comprises a plurality of detectors, each arranged to image a scene from a different direction.
24. A ranging apparatus as claimed in any of claims 20 to 23 wherein the processor applies image processing algorithms to the scenes from each viewpoint to determine range information therefrom.

25. A ranging apparatus as claimed in any of claims 20 to 24 wherein the detector means is adapted to have a different baseline to the illumination means in each viewpoint.
26. A ranging apparatus as claimed in any of claims 20 to 25 wherein the processor is adapted to determine the possible range to the scene from each viewpoint and compare the possible ranges to resolve any ambiguity.
27. A ranging apparatus as claimed in any of claims 20 to 26 wherein the baseline of at least two of the viewpoints lie along different axes.
28. A ranging apparatus as claimed in any preceding claim wherein the apparatus further comprises a plurality of illumination means arranged to illuminate the scene from different directions.
29. A ranging apparatus as claimed in claim 28 wherein the apparatus is adapted to periodically change the illumination means used to illuminate the scene.
30. A ranging apparatus as claimed in claim 29 wherein the processor is adapted to determine the possible range to the scene when illuminated with each illumination means and compare the possible ranges to resolve any ambiguity.
31. A ranging apparatus as claimed in any of claims 28 to 30 wherein each illumination means is arranged to have a different baseline to the or each detector or detector array.
32. A ranging apparatus as claimed in any of claims 28 to 31 wherein at least two of the illumination means project spots having different characteristics.
33. A ranging apparatus as claimed in any preceding claim wherein the illumination means comprises a light source arranged to illuminate part of the input face of a light guide, the light guide comprising a tube having

substantially reflective sides and being arranged together with projection optics so as to project an array of distinct images of the light source towards the scene.

34. A ranging apparatus as claimed in claim 33 wherein the light guide comprises a tube having a square cross section.
35. A ranging apparatus as claimed in claim 33 or claim 34 wherein the light guide comprises a tube having reflective internal surfaces.
36. A ranging apparatus as claimed in claim 33 or claim 34 wherein the light guide comprises a tube of solid material adapted such that a substantial amount of light incident at an interface between the material of the tube and surrounding material undergoes total internal reflection.
37. A ranging apparatus as claimed in any of claims 33 to 36 wherein the projection optics comprises a projection lens.
38. A ranging apparatus as claimed in any of claims 33 to 37 wherein the light source is arranged to illuminate the input face of the light guide through a mask.
39. A ranging apparatus as claimed in any of claims 27 to 31 wherein the light source illuminates the input face of the light guide with a non-circular shape.
40. A ranging apparatus as claimed in claim 32 wherein the light source illuminates the input face of the light guide with a shape which is non-symmetric about the axes of reflection of the light guide.
41. A ranging apparatus as claimed in any of claims 33 to 40 wherein the illumination means comprises more than one light source, each light source arranged to illuminate part of the input face of the light guide.

42. A ranging apparatus as claimed in claim 41 wherein the light sources are arranged in a regular pattern.
43. A ranging apparatus as claimed in any of claims 41 or 42 wherein the light sources are arranged to provide differing spot densities.
44. A ranging apparatus as claimed in any of claims 41 to 43 wherein at least one light source emits light at a different wavelength to another light source.
45. A ranging apparatus as claimed in any of claims 41 to 44 wherein at least one light source is shaped differently to another light source.
46. A ranging apparatus as claimed in any of claims 41 to 45 wherein at least one light source has a shape which is not symmetric about a reflection axis of the light guide.
47. A ranging apparatus as claimed in any of claims 41 to 46 wherein at least one light source is located within the light guide at a different depth to another light source.
48. A ranging apparatus as claimed in any preceding claim further comprising a means for periodically redirecting the array of spots in the scene.
49. A ranging apparatus as claimed in any preceding claim further comprising a location sensor.
50. A proximity sensor incorporating a ranging apparatus as claimed in any of claims 1 to 49.
51. A target identification apparatus incorporating a ranging apparatus as claimed in any of claims 1 to 49.

52. An intruder detection system incorporating a ranging apparatus as claimed in any of claims 1 to 49.
53. A biometric modelling apparatus incorporating a ranging apparatus as claimed in any of claims 1 to 49.
54. A document scanner comprising an imager and a ranging apparatus as claimed in any of claims 1 to 40, wherein the imager is adapted to process the range information from the document to determine the extent of curvature thereof and process the detected image to correct for any curvature.
55. An image recorder having a large depth of field comprising an illumination means for illuminating a scene with an array of spots and an imaging array for recording an image of the scene characterised in the illumination means is adapted to illuminate the scene such that the location of spots in the recorded image can be used to give a determination of range without any ambiguity.
56. A method of obtaining range information about a scene comprising the steps of illuminating the scene with an array of spots, taking an image of the spots in the scene, uniquely identifying each spot in the scene and determining, from the location of each spot in the scene the range to that spot.
57. A method of obtaining range information about a scene as claimed in claim 56 wherein the step of illuminating the scene comprises the step of illuminating the scene with spots which have a non-circular shape and which are focussed at one range and unfocussed at another range and the step of uniquely identifying each spot in the scene involves determining whether the spot is focussed or not.
58. A method of obtaining range information about a scene as claimed in claim 56 or claim 57 wherein the step of illuminating the scene comprises the step of

projecting an array of spots such that at least some of the projected spots are of a different shape and/or colour to other spots and the step of uniquely identifying each spot in the scene involves determining the colour and or shape of a spot.

59. A method of obtaining range information about a scene as claimed in any of claims 56 to 58 wherein the step of recording an image of the scene comprises the step of recording an image of the scene from a plurality of viewpoints with the same illumination.
60. A method of obtaining range information about a scene as claimed in claim 59 wherein the step of uniquely identifying each spot in the scene comprises the step of comparing the position of a spot from more than one viewpoint so as to uniquely identify that spot.
61. A method of obtaining range information about a scene as claimed in any of claims 56 to 60 further comprising the step of recording information about the position from which the image was recorded for each recorded image.
62. A method of identification comprising the step of obtaining range information about a scene according to any of claims 56 to 61 and comparing said range information with reference shape information corresponding to an item to be identified and giving an indication of quality of match of the detected shape to the reference item.
63. A method as claimed in claim 62 wherein the matching step uses model coefficients or best fit methods.